TWO RECENT IMPORTANT CABBAGE DISEASES OF OHIO

OHIO

Agricultural Experiment Station

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BULLETIN 228

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BULLETIN
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Ohio Agricultural Experiment Station
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TWO RECENT IMPORTANT CABBAGE DISEASES OF OHIO

By THOS. F. MANNS

INTRODUCTION

Many areas in Ohio have soils which are well adapted to trucking crops or other lines of intensive culture. The number of large cities, together with excellent shipping facilities, greatly stimulates such enterprises. As a rule these districts, when carefully managed, have paid the investors good returns upon their investments. Too often, however, the history of the districts exploited for certain intensive cropping, with their manufacturing plants for utilizing the products, has been that of final failure. Under intensive culture, where large profits are apparently assured, the tendency is to select the better part of the farm, keep it abundantly fertilized, and practice close or continuous, one-crop culture.

ONE-CROP CULTURE OFTEN FATAL

There are but few of our many crops which may be grown successively on the same area without sooner or later bringing about soil sickness by the introduction of many persistent fungus and insect enemies. Fig. 1 shows a field cropped for the first time with cabbage—18 percent sick with "yellows"—Fusarium wilt; 6 percent sick with "black-leg"—Phoma wilt. Among the very few crops which partially withstand successive cropping, corn probably suffers the least. Aside from the probability of causing "soil sickness", other good reasons may be mentioned why the one-crop culture should be little practiced; among these is the cost and difficulty of maintaining a balanced food supply. Like the proverbial chain which is no stronger than its weakest link, a soil in no wise can produce a larger yield of a particular crop than is made possible by the total available amount of a certain plant food low in that soil. For example, a soil, in which the possible potash availability is sufficient to produce only 50 percent of a cabbage crop, will be limited to but half a crop, no matter how much money may be expended for other fertilizing elements.

The one-crop culture makes heavy demands upon certain plant foods, e. g., cabbage in its needs for potash. On the other hand a proper rotation distributes these demands and allows of longer periods for making available the necessary elements. Hence, the rotation is more likely to have ready the required plant foods, than is the one-crop culture.

Also, there are good reasons why cultivated crops, such as corn, potatoes, cabbage, beans, beets, onions, etc., should be made a part of a rotation rather than otherwise, because of the opportunity the extra cultivation affords of incorporating organic materials (manures, etc.) into the soil, and of leaving the soil in a better tilth.

After the important features of proper rotation and fertility maintenance have been worked out, probably the next in order is the

IMPORTANCE OF SEED AND THE SEED BED

The object of this bulletin is to call the attention of cabbage growers in particular, and truck growers in general, to the possible means of avoiding or preventing the further spread of certain fungus parasites which may, and do, exist as persistent soil troubles.

Fig. 1. Showing a field cropped for the first time with cabbage. 18 percent sick with "yellows" (Fusarium wilt). 6 percent sick with "black-leg" (Phoma wilt). The diseases present were transferred directly from the seedbed.

Great progress has been made during the past twenty years in the knowledge of plant diseases, their modes of infestation, their means of continuing from season to season, and their manner of distribution. As a rule, there are usually loop-holes in the life history of parasites through which economic control is possible. As in the old adage, however, "an ounce of prevention", etc., is playing a far more important part in the control of plant diseases than is treatment after the disease becomes active.

Among the annual crops, as far as the possible introduction of persistent fungus soil troubles is concerned, an insight into the seed and seed bed is often of first importance. Is the seed carrying the specific fungus trouble? If so, is there a seed treatment that will destroy the spores of the disease? Second, is the soil already infested where the seed is to be planted? Often a knowledge of these facts, when properly applied, makes the difference between success and failure. "Experience", certainly, "is a dear teacher," when through this process we learn that after a certain plant disease has gained a foot-hold in our fields, it means we must drop from cultivation, for a decade or more, a crop which previously has been a money maker. This is exactly what the Fusarium wilt ("yellows") of cabbage in our soils signifies.

HISTORY AND EXTENT OF CABBAGE CULTURE IN OHIO

Cabbage in Ohio has been grown by market gardeners in the vicinities of the larger cities for a long time. Only within the past twenty-five years has there been a tendency among farmers in certain districts to make this an extensive crop. Much difficulty is encountered in obtaining accurate data on the extent and value of the cabbage crop, as owing to its minor importance no statistics have been taken.

One of the largest cabbage districts includes the vicinities of Clyde, Greenspring, Fremont and Bellevue, (Seneca and Sandusky counties) where the kraut industry is quite extensive. Three factories are located at Clyde, and one each at the other towns mentioned. All these factories have sprung up within the past twenty years; several within the last eight or ten years.

With the exception of a few carloads of cabbage which are purchased by outside buyers and shipped to Cleveland or other large cities for direct consumption, the large bulk grown in this district is made into kraut. It is estimated that between 3,000 and 4,000 acres are annually put to cabbage. The average annual yield varies from six to nine tons per acre. The price fluctuates considerably, that is, from $5 to $12 per ton, with an average of about $6. Under favorable conditions an average yield of twelve tons may quite readily be reached. Many of the growers maintain that a cabbage crop of 9 tons per acre is a better paying crop than corn, wheat or oats under fair yields.

During the past few years, considerable stimulus has been given the growing of cabbage, through the kraut factories previously mentioned, offering to contract at fair prices all the cabbage grown.

There is always a good demand in the large cities in late summer and early fall for cabbage. It is very difficult to get data of the acreage, yield and average value of the crop grown by those who cater to these demands. The prices vary greatly according to the season and the location. The price per ton, as indicated by fifteen correspondents catering to city trade, varies from $8 to $20. The total acreage devoted to cabbage in Ohio probably does not exceed 8,000 to 10,000 acres. This area, however, represents a value sufficient to demand statistics.

CABBAGE IN OHIO A SHORT-LIVED CROP

The history of cabbage culture in the several districts of the state points to the crop as being very short lived. Some of the quickly lowered yields have resulted from rapid soil exhaustion. Few of the growers realize that 15 tons of cabbage per acre removes from the soil three times the quantity of plant food (nitrogen, phosphoric acid and potash) required for a crop of 20 bushels of wheat. This factor, however, has been secondary in shortening the life of the crop. The chief cause of failure has been the introduction and spread of several severe cabbage diseases. Chief among these heretofore, appears to have been the brown or black-rot. Quite recently, however, two apparently new troubles have made their appearance. These latter have become very active and disastrous in the districts about Clyde and Greenspring. In the newer cabbage districts of Fremont, and the outlying areas some distance from Clyde, Greenspring and Bellevue, these diseases have made their appearance, though to a limited extent. The preliminary method of distribution, viz., through infested seed beds, would seem to offer means of partial control. The chief object of this bulletin is to acquaint growers with these cabbage troubles, point out their manner of distribution, and call attention to practices which will aid in their elimination or control.

CABBAGE DISEASES—THEIR DISSEMINATION AND CONTROL

There are four diseases in the state which are very active in reducing the cabbage crop. These are (1) Brown or Black-Rot, a bacterial disease, (2) Club-Root, a slime mold disease, (3) Fusarium Wilt, known also as "yellows", a fungus disease, and (4) Black-Leg or Foot-Rot, known also as a wilt, and likewise a fungus trouble.

The two first named diseases have been known throughout the state for a number of years and their severity is fully apprehended. The two latter named troubles, which apparently have been active

with us for some six years or more, have but recently been studied at this Station. It is quite beyond us to tell why certain organisms should have adapted themselves to a life of parasitism. But, on the other hand, it is usually not difficult to discover the means of dissemination. Of the four above-mentioned diseases there is no evidence whatever that any one is carried internally in the seed (within the seed coat) and the possibility of such being the case is far remote. There is no reason, however, why the seed may not externally carry the spores or fruiting bodies of, at least, the three last named of the above diseases. From examinations of washings of fifteen samples of seed, by aid of the centrifuge and microscope, no evidence was found indicating that externally the seed was carrying disease; yet, in order to eliminate the possibility of disease reaching the seed bed in this manner, the writer advises *the treatment* of all seed just previous to sowing. Soak the seed twenty minutes in a solution of one part formaldehyde in 320 parts of water* (1 oz. of 40 percent formaldehyde in 2 1-2 gallons of water). The cost is practically nothing. The treatment eliminates the possibility of the seed carrying disease, while, on the other hand, it is beneficial rather than injurious to the seed. This advice is given, looking toward entire prevention of these diseases getting a foothold in the seed beds. *Under no circumstances should the seed bed be located on an area on which cabbage has recently been grown*, nor upon land that at any time has been known to have had sick plants upon it. The seed bed should be located at a considerable distance from buildings near which cabbage has been hauled, stored, or the refuse parts fed.

It is now known that all four of the diseases named on page 258 are caused by parasites, which in themselves are more or less persistent soil organisms. Their introduction into non-infested fields or localities may and does come about through one or several of the following ways:

1 Through the seeds carrying the spores of the disease on their surface.

2 Through shipment of cabbages, celery, onions, potatoes and other truck crops carrying the disease from cabbage-sick districts; the wastes of these products finally reaching gardens or fields which later are used as seed beds for cabbage.

3 Through transfer of seedling cabbage and celery grown on cabbage-sick soil.

4 Through manures in which diseased cabbage material has been thrown, or carried on the feet of men, of work animals or of other stock.

*Experiments conducted August 23, 1910, and following show that cabbage seed will stand heavy treatment with formaldehyde.

5 Through machines, plows, drags, cultivators, etc., being taken from sick fields to those not infested.

6 Through transferring the disease in handling seedlings, making infection possible by bruising, or the breaking of the leaves.

7 Through insects, such as the adults of the cabbage or radish maggots, lice, and others. Especially does this seem true of the Black or Brown Rot of cabbage, a bacterial disease, and the black-leg.*

8 Through wind and running water.

GENERAL TREATMENT

Having enumerated above the ways in which these diseases are likely to be disseminated, the next question is, what measures may be used in their control? In new localities adapted to cabbage, and areas distant from infested localities, the problem is not a difficult one. Treatment of seed previous to planting should be practiced. In nowise should cabbage, cauliflower or celery seedlings be purchased unless known to have been grown on soil free from cabbage diseases. Care should be taken to see that no manures are used containing cabbage or other truck crop litter. The seed bed should always be placed on a new and somewhat distant area each year. A satisfactory rotation should be practiced, for example: wheat, clover, cabbage and corn; the second crop of clover to be left and the sod to receive 15 to 20 tons of manure; this to be supplemented, at the time of preparation, by an application of 300 to 600 lbs. of a first grade, complete fertilizer high in potash. Two to four hundred pounds of common salt is also recommended. The lime content of a cabbage field should always be kept high. In case manure cannot be obtained, the turning under of a clover crop, supplemented by 700 to 900 lbs. of a complete fertilizer high in potash is to be recommended. Where commercial fertilizer, alone, is to be relied upon, fully 2000 lbs. of a mixture of 400 pounds each of nitrate of soda and muriate of potash with 1200 pounds of acid phosphate should be used if a maximum crop is to be expected.

WHAT TO DO IN AREAS ALREADY INFESTED

Too much emphasis cannot be placed upon the persistent nature of these organisms when once placed in the soil. Though no complete data are to be found indicating the length of time any one of these organisms may persist in the soil without the intervention of a cabbage crop, the evidence is quite sufficient to show

*In the following references, insects have been recognized as agents in the distribution of diseases.

[1]Smith, Erwin F., The Black Rot of the Cabbage, Farmers' Bulletin 68: 1898 U. S. D. A.

[2]Zeitschrift fur Pflanzenkrankheiten, 16: 257-276; 1906, "Krebstrunke" and "Fallsucht" bei den Kohlpflanzen, verursacht von *Phoma oleracea* Sacc , by Prof. J Ritzema Bos (Wageningen.)

[3]Zeitschrift fur Pflanzenkrankheiten, 17: 258-267, 1907. Neue Kohlkrankheiten in Nord Holland, by Dr H. M. Quanjer, (Wageningen.)

that six to eight years will not be adequate to remove the organism of the Fusarium wilt. In the case of the other troubles, they may not be quite so persistent; this much is true nevertheless, proper rotations, in which are included grass or grain crops, are the only means known at present to remove these diseases from the soil. A partial exception should be made in the use of lime for the prevention of club-root. There are always to be found, in cabbage-sick districts, some fields which have not yet become infested. Only through the greatest precautions can such fields be kept from becoming diseased. The seed beds must be kept free from disease. Two or more seed beds in different places may be started, and plants only from the healthiest be used. Tools, machinery and animals should not be taken directly from infested fields to those not infested, as this will be a sure way of distributing disease. The cleaning of implements after use in infested fields should be practiced. Cattle, sheep or other stock should not be allowed to pasture promiscuously from infested to non-infested fields. In no wise should manure containing cabbage litter, or made by animals running over sick fields, be used on non-infested areas. These precautions may seem rather severe, but the writer's experience with the distribution of flax-wilt (a Fusarium disease) in the northwestern states has emphasized the old adage, "Eternal vigilance is the price of clean land." In this respect, a persistent soil disease should be regarded as even more disastrous than a noxious weed; the latter may be uprooted, while the former requires 4 to 10 years or more of systematic cropping for its elimination.

Some knowledge of each of these specific diseases is required in order to practice the most effective methods for their control and prevention. In the description given below of each of the particular troubles, further precautions or recommendations are given, which apply to each disease specifically. In case of doubt as to methods of procedure, or as to identification of the trouble, the experience of the Department of Botany at the Experiment Station should be called into service.

WILT, FUSARIUM WILT OR YELLOWS OF CABBAGE

Fusarium sp.

This disease has been known in the eastern cabbage districts for some time, though little has been done upon it by scientific workers. Recently Mr. L. L. Harter[4], of the United States Department of Agriculture, has published in *Science* results of infection and other experiments in which the causative organism is shown to be a fungus of the genus Fusarium. Dr. E. F. Smith first called attention to this trouble in 1895.

We have experienced no difficulty in obtaining the Fusarium parasite from the sick plants. In infected seedlings or the early stages of the disease more success is met with in securing cultures free from contamination (See Figs. 13 and 14, p. 274). Cabbage specimens from a number of fields in the vicinity of Clyde, Sandusky county, have yielded the fungus. The other localities from which infected plants (giving the organism in cultures) have been obtained, are Greenspring, Seneca county; Fremont, Sandusky county; Englewood, Montgomery county, and Armenia, Washington county. The disease has also been reported from St. Bernard, Hamilton county; Waynesburg, Stark county; Orrville, Wayne county; Lodi, Medina county, and Newark, Licking county.

This disease has not been reported in Europe to the writer's knowledge.

The severity of the disease in the vicinity of Clyde and Greenspring makes it imperative that precautions be taken at once to check its distribution, or the cabbage industry will soon be one of history so far as these vicinities are concerned.

For just how many years this disease has been active in these localities is hard to determine. By inquiry among the more observing of those who have grown cabbage a number of years, the evidence seems sufficient to indicate that for six to eight years the trouble has been making considerable headway in decreasing the yields. The persistent nature of the organism as a soil trouble further indicates that six to eight years of other than cabbage cropping is not sufficient time to remove it. In other words, a field which has become thoroughly sick with this disease will not again be capable of producing a healthy or satisfactory crop of cabbage in six to eight years. Other crops, excepting, possibly, cauliflower, mustard and related plants, will do well upon cabbage-sick land. The length of time required to remove this organism from the soil has not been determined. With heavy manuring and tilled

[4]Science N. Ser. 30· No. 782, p 934, 1909.

crops, probably fifteen years will not do it. With much grass and grain cropping, probably ten years will suffice. Permanent grass pasture will do the work in the shortest time.

LOSSES FROM THE FUSARIUM WILT

The severity of the disease depends wholly upon the amount of soil and seed bed infestation. Usually in new fields, when the seed bed is but lightly infested, the losses the first season seldom reach higher than 2 to 5 percent. However, should the seed bed be badly infested, sometimes 50 percent of the plants wilt within a week or ten days following the transplanting. Where fields have become badly infested, the injury may reach 95 percent or even total loss. (See Fig. 2, showing part of a 10-acre field in which the cabbage was so sick the owner had ceased cultivating, and was allowing grass and weeds to take the field. The yellowing of the foliage together with the dropping of leaves are characteristic of the Fusarium wilt. The loss in this field was practically total. Fig. 3 illustrates a field carefully cultivated, though 75 percent of the plants were already down, Aug. 4, 1910).

Losses of from 50 to 80 percent are to be seen in the older and badly infested fields. The rapid progress of the disease in badly diseased areas is exceedingly discouraging to growers. One field, which had not previously been in cabbage for eight years, showed marked symptoms of sickness, and a loss of 30 percent was estimated. Much of this sickness appeared to be carried over from the crop of eight years before.

SYMPTOMS OF THE DISEASE

This trouble in the vicinity of Clyde is known as "yellows"—this term being applied because of the external appearances. In diagnosing the disease, this color characteristic is the first symptom to be relied upon. Later, a stunted growth, with a tendency of the lower leaves to drop at the lightest touch is further evidence of the disease. To the keen observer these symptoms may be detected in the seed bed previous to transplanting (See Figs. 9 and 10, pp. 270 and 271). In these early stages, the fungus responsible for the disease may be taken out in pure culture by artificial media. Later, bacterial contamination takes place. (See Figs. 13 and 14, p. 274.) Plants which show the symptoms in the seed bed, upon being transplanted, make no further growth, they simply wilt, turn black, and the lower leaves usually fall off.

After setting out, the healthy plants are attacked at all stages of their growth. In the older and later infected plants, the preliminary symptoms are similar to those in seedlings; yellowing of the lower and outer leaves takes place; these leaves later drop, turning a drab color, the lowest first, being followed successively at different times by others in their order (See Fig. 4, p. 265).

Fig. 2. The plants at the center and left are infested with the Fusarium disease. Note how the leaves have wilted and dropped from the plant at the center.

Fig. 3. Note the two plants in the center and left foreground that have died with Phoma wilt, "black leg" disease. Fully 75 percent of the plants had wilted from "black-leg" and "yellows" previous to photographing.

Photographed August 4, 1910, Clyde, Ohio

Fig. 4. Showing the difference between the work of the Fusarium Wilt (yellows), plant at center and the Phoma wilt (black leg), plant at right. A complete collar rot had taken place in the latter plant.

In older plants, sometimes stumps nearly full size may be seen that have shed all their leaves (See Fig. 8, p. 269, illustration at left.) This deciduous nature of the leaves is very characteristic of the Fusarium wilt. No broken lesions are to be noticed on the stems and roots unless decay (bacterial and fungus complication) follows, which does occasionally take place.

In the case of bacterial association the plant may show a very quick wilt. Sometimes, when the disease has gained entrance to the vessels in one part of the cabbage, the yellowing symptoms may show only on one side. Under such circumstances, a sunken but unbroken lesion may be observed indicating the course of the fungus (See Fig. 6, page 267). Cross sections of infected stems and roots, when not complicated with bacterial activity, show a light yellowing or browning of the vessels. The presence of bacteria in the vessels changes this coloring to a dark brown or jet black. This coloring of the vessels in advanced cases extends clear up into the petioles of the leaves. By cultures, it is not difficult to demonstrate that the fungus actually penetrates the petioles, thus definitely proving that fallen leaves are a means of disseminating the disease. Maturing plants which have become sufficiently infected to show external symptoms, are not accepted as marketable by buyers.

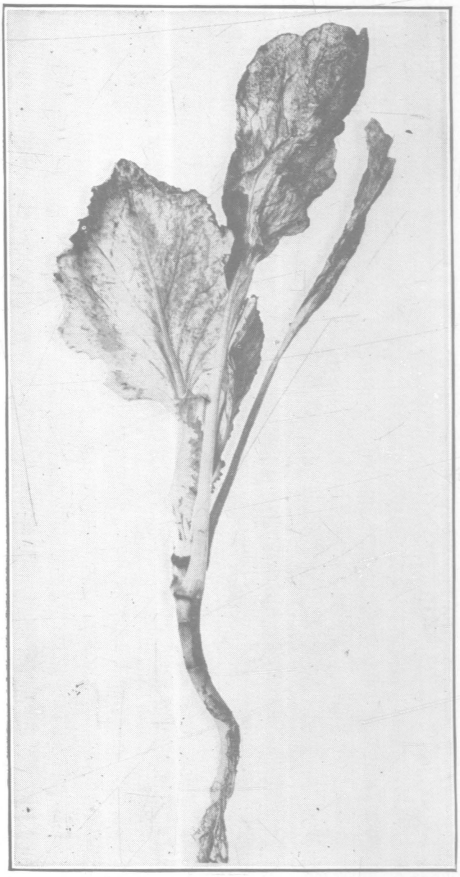

Fig. 5. Cabbage seedling showing the yellowing symptoms of Fusarium wilt (See Fig. 10).

INFLUENCE OF SOIL AND WEATHER

This disease is less influenced by soil and weather conditions than are most other fungus troubles. The growers state that the lighter, sandy soils greatly favor the spread and activity of "yellows". There is some evidence which supports these statements. A light sandy field east of Clyde, which on August 4th showed about 1 percent infected with the Fusarium wilt, on September 13th showed between 15 and 25 percent wilted. A nearby field consisting of low, black soil, which on the first date showed 15 percent sick with Fusarium wilt, had increased but little by the latter date. The Fusarium wilt of flax, a similar disease, in the northwestern states makes much more rapid progress in the lighter soils of central North Dakota, than in the heavy, black soils of the Red River Valley.

An abundance of humus favors its spread and persistance in the soil. However, in this regard it is evident that soils which are in any way suitable for cabbage will contain sufficient organic material to supply the needs of this organism. Excessive rains are always a means of distributing soil troubles. In this regard the Fusarium wilt of cabbage is no exception. Droughty conditions limit surface distribution, while on the other hand, the aggressive nature of the disease is always aggravated by dry weather.

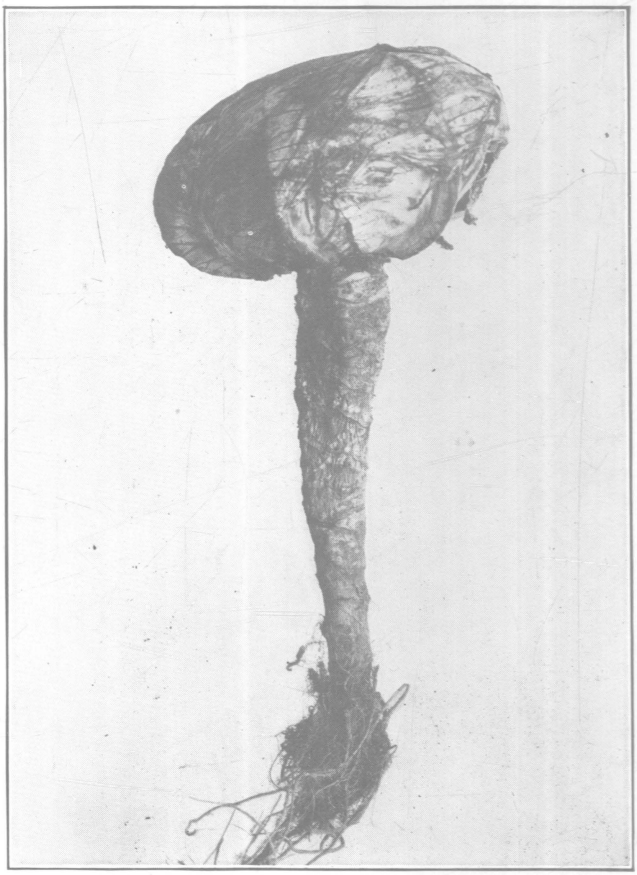

Fig. 6. A partially matured plant that has succumbed to the Fusarium wilt. In the upper shaded part of the stem is a sunken area showing the course of the disease.

TREATMENT

Parasitic diseases of field crops which are also persistent soil organisms seldom admit of definite treatment economically. In the case of club-root of cabbage the causal organism gradually succumbs to heavy applications of lime. Potato scab, on the other hand, is increased by lime. In the case of cabbage wilt (Fusarium) no specific treatment is known.

Fig. 7. Illustration showing the external characteristics of Phoma wilt (black leg). The seedling at the left shows the lesions as they appear on the stem, often previous to transplanting. In these sick spots are found small black bodies, the fruit (pycnidia) of the fungus which causes the disease. At the right is shown a partially matured plant that has just collapsed from the disease. Note how the stem and main root have been practically rotted off. In this case, no adventitious roots have been sent out. (See Fig. 18 for adventitious roots). Compare this illustration with Figs. 5 and 6 for contrast of Phoma (black leg) and Fusarium wilts (yellows).

MEASURES LOOKING TOWARD CONTROL

Though no specific treatment has, as yet, been worked out, there are many preventive or restrictive measures which may be practiced. In addition to those recommended (pp, 260, 261) the following should be carried out: Diseased plants should be gathered and burned or dumped in places from which no further spreading is assured. Small diseased areas should be worked entirely separate from the field as a whole, in this way preventing distribution by implements and animals.

Fig. 8. Comparing at the left, stem of plant defoliated by the Fusarium disease, with plant at right affected with the Phoma wilt. Note, that the plant at the left shows no rot on the stem, while the plant at the right has broken at the stem due to rot from the Phoma disease. Both plants are the same age, about one-third grown.

It is important to become familiar with the disease in all its symptoms, to be able to detect the first signs of the disease in the seed bed; and to absolutely avoid using plants from beds in which even the slightest trace of the disease appears. The practice of

putting out two or three seed beds on non-infested areas is to be recommended. This will give an opportunity to select the least infected and most vigorous plants. We must keep in mind that the seed bed is a minor expense. To be limited to weak and infected plants is a heavy handicap.

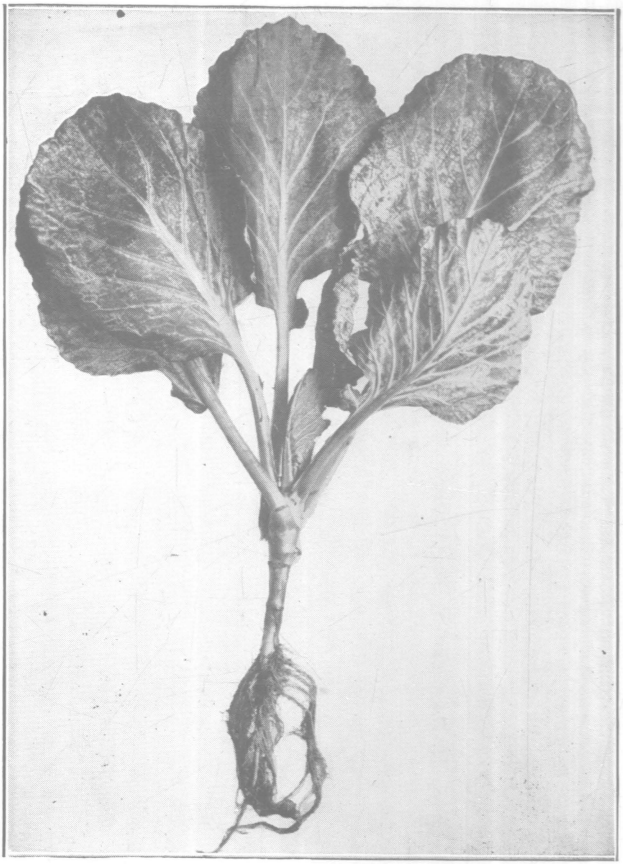

Fig. 9. A healthy cabbage seedling. Compare with the plant shown in Fig. 10, which was taken from the same bed, and was of the same age.

In case a few scattered infected plants are discovered in the field, these should be carefully removed and immediately burned or otherwise destroyed. The disease spots should be marked and all to and fro cultivation over these infested areas should be stopped to prevent distribution by implements. Where the disease makes its appearance, rotation should early be practiced. An accurate record should be kept of the amount of disease which appears in the fields cropped with cabbage, so that when the rotation again brings the land into cabbage an estimate may be made as to whether the disease is on the decline or increase.

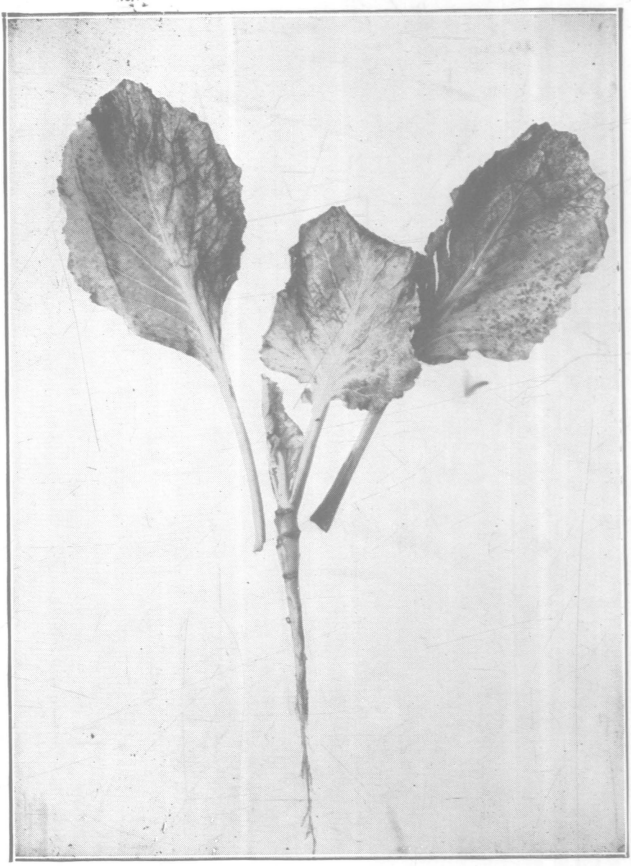

Fig. 10. A cabbage seedling affected with Fusarium wilt, (yellows). The yellowing leaves drop at the slightest touch.

THE POSSIBILITY OF SELECTING RESISTANT STRAINS

Much hope is to be entertained of the possibility of securing resistant strains. This is a work that requires several years for positive results. Sometimes it is desirable even after securing resistant plants to cross-breed these with marketable strains, as it is often the case that resistant strains or varieties are not high yielding or of desirable quality. It would even seem profitable for growers to continue desirable strains, by selecting those of the proper type and yielding capacity. The practice of purchasing

seeds from promiscuous retailers often proves a risky business. One need be no specialist to note that many irregular types, and low quality, poor yielding strains are to be found throughout the cabbage districts. This difficulty can be remedied only by purchasing from reliable seed houses, or by the growing of seed from carefully selected, home grown stock.

Fig. 11. Showing at the left plants slowly dying with the Fusarium wilt. In this field the disease was general, and the loss was excessive. The plants were not quite half-grown. Note the manner of shedding the leaves. *Photographed August 4, 1910, Clyde, Ohio*

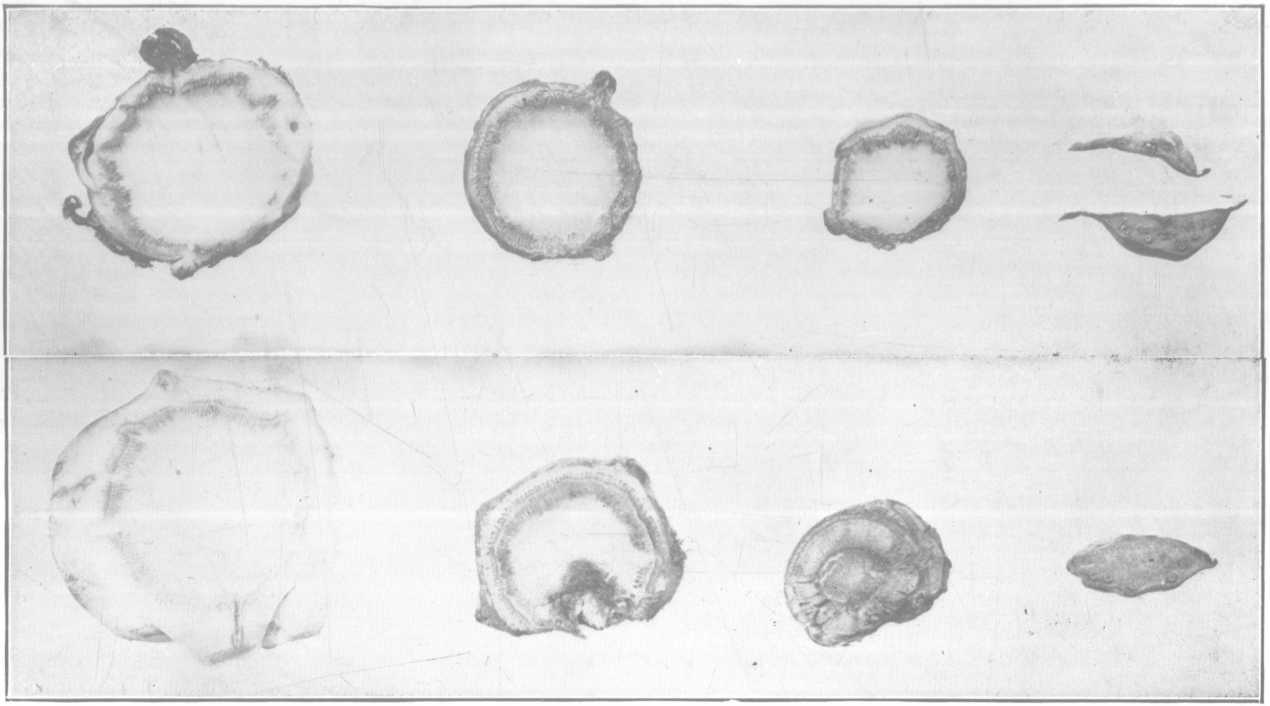

Fig. 12. Showing above, cross sections of a plant infected with the Fusarium disease. The vessels throughout the root and stem have a yellowish to brownish color; this discoloration often extends up into the petioles of the leaves. The fungus may be taken from the petioles by plate cultures, showing that dropping leaves are a means of distributing the disease.

The cross sections below are from a Phoma sick (black leg) plant. The heart shows no discoloration, indicating that the disease works lower down. The chief injury takes place on the stem and root at the level of the ground, or below, where a collar and stem rot is produced.

Fig. 13. Showing plate cultures of the Fusarium fungus which causes wilt or "yellows". From a young seedling just showing the preliminary symptoms; in this case a pure culture of the parasitic organism is seen.

Fig. 14. Cultures of the Fusarium wilt fungus from an older infected seedling in which bacterial association had already taken place. As soon as bacterial contamination takes place the seedling rapidly wilts. The bacterial growth in the plate has checked somewhat the growth of the parasitic fungus.

SUMMARY

In summarizing, the following suggestions are emphasized:

1 Learn to know the Fusarium wilt in its earliest symptoms, and to distinguish it from the other cabbage troubles.

2 To assist you, your Experiment Station is always ready. Send in specimens of diseased plants; ask for advice, literature or a personal visit.

3 Treat the seed (see page 259); grow your own plants; put out two or three seed beds a considerable distance from any infested areas; use only the most healthy and vigorous plants.

4 Use no plants from a Fusarium wilt (yellows) infested bed.

5 Use no manures carrying infested cabbage litter.

6 Should light infestation appear in the field, gather all sick plants and burn. The diseased spots should be marked off and cultivated separately. Keep a written record of the infested field, noting the infested spots. In this way you will learn the kind and length of rotation required to work out the disease.

7 Practice rotation upon the appearance of disease. A good rotation pays at all times.

8 If you are interested in continuing cabbage culture, never allow stock to feed promiscuously from infested to non-infested fields.

9 "An ounce of prevention", with this disease, "is worth a *ton* of cure."

10 Early learn to know the persistent nature of this disease as a soil trouble, and likewise, the improbability of working out a curative treatment.

BLACK-LEG OR FOOT ROT OF CABBAGE

Phoma oleracea Sacc.

This disease may have reached us from European countries where it has been known for a number of years. France, especially, has lost heavily from what appears to be the same trouble.[5] In the Province of South Australia, vicinity of Auburn, growers of cabbage and cauliflower, especially the latter, have recently met with considerable losses from this disease.[6] Germany, likewise, has been subject to the trouble for sometime. More recently the disease has made its appearance in North Holland, where it has been made the subject of extensive experiments.

In the state of Ohio the disease has been known for only a short time, the attention of the Department being called to the trouble by the writer on a visit to Fremont, Sandusky county, during the spring of 1910. The seed beds showed considerable infestation previous to the time of transplanting (See Figs. 15, 16 and 17, pp. 279, and 280).

During the summer, through letter and visitation, the writer has found that the disease has made its appearance throughout Ohio in a number of places. Specimens have been received from Fremont and Clyde, Sandusky county; Greenspring, Seneca county; and Englewood, Montgomery county, and correspondents further report the disease from Hamilton, Medina, Washington, and Ashland counties.

THE DISEASE IN EUROPE AND AUSTRALIA

The literature upon the disease is very limited. Prillieux and Delacroix[7] give a careful description of the disease as it appears in western France in the Province of Vendeé on the cabbage grown for fodder. They designate the trouble, "Foot-Rot of Cabbage" (Pourriture des pieds de Chou) and state that the disease is of considerable importance, attacking and rotting the stems, causing much loss. The fungus assigned as the source of the trouble is *Phoma Brassicae* Thüem. In Australia, the disease has been carefully studied by D. McAlpine[6], who calls the

[5]Dept. of Agr., Victoria, Fungus Diseases of Cabbage and Cauliflower in Victoria, and their Treatment, by D. McAlpine, January 1901.

[6]Prillieux and Delacroix, Bul. de Societe Mycol. 6: p. 114, 1890, also Maladies des Plantes Agricoles 2: 295-297, 1897.

[7]Prillieux, Maladies des Plantes Agricoles, 2: 295-297 1897.

trouble "Black-leg" or "Foot-rot" and states that, in 1901, cauliflower in some instances suffered losses of 25 percent or more. He says:

"This cauliflower disease was also met with at Brighton, and Mr. Cronin, inspector under the Vegetation Disease Act, called attention to the serious nature of it in June of this year, stating that fully 90 percent of the plants were affected in some instances, and estimating the loss in the Brighton district at £5,000 ($25,000), one grower alone sustaining a loss of £200 ($1,000). I visited this district in August, and found the disease not only on cauliflowers, but also on cabbages."

In speaking of the severity of this disease, after mentioning four other diseases, viz., Club-Root, White-Rust, Ring-spot of Leaf, and Putrefactive Mildew, he says:

"The 'Black-leg' is perhaps the most serious trouble with which the grower has to contend, and the neglect of it for a number of years past, combined with the encouragement given to its spread by ignorantly plowing in the diseased portions, has given it a strong foot-hold in the (Brighton) district."

He notes that the disease causes collar-rot of the roots and stems of cabbage and cauliflower, and that it is not uncommon to find it upon the leaves of these plants, and also upon those of turnip and rape. He states:

"In every instance the superficial tissue of the diseased roots and stems showed numerous black punctiform bodies, which usually did not extend above ground."

He assigns the fungus *Phoma Brassicae* Thüem as the causal agent.

In the Province of North Holland, vicinity of Langendijk, the disease is known in two forms: one, a field trouble, is given the name "Fallsucht" that is, drop disease or falling sickness, (See Cit. 2 and 3 p. 260) signifying the characteristic termination of the disease (See Fig. 4 p. 265, cabbage at right); and the other a storage trouble called "Krebsstrunke" (cancerous stems), in which, during February and March, yellowish-gray, cancerous spots appear in the axis of the leaf and extend onto the leaves. (See Fig. 19, p. 283, showing sick spot on growing plants). These lesions increase till the leaves rot off. In reviewing the trouble in the Province of North Holland, Professor Bos (see Cit. 2, p. 260) says:

"The neighborhood of Langendijk is really the center of cabbage culture in Holland. Here, year after year, so much cabbage is grown that a proper rotation is impossible; upon many of the fields cabbage has been continued for twenty years. Thus one can understand that many diseases must come in; one really wonders that these diseases do not take the upper hand and make cabbage culture an impossibility."

In speaking of the trouble he states that the chief symptom of this disease consists in the dying of the main root, close to the surface of the earth, and notes that the disease in the field may be distinguished by the bluish-red color of the leaves. He attributes the disease to the fungus *Phoma oleracea* Sacc.

SYMPTOMS

The work of the disease is early noticeable in the infected seed beds, being often conspicuous one or two weeks before transplanting. The preliminary symptom is that of white, sunken, elongated oval areas on the stem, usually below the point of leaf attachment (See Figs. 15, 16 and 17, pp. 280, and 281). There appear early in these lesions, small black bodies equally distributed over the affected areas; these black specks are the fruiting bodies (pycnidia) of the fungus. Within each pycnidium are myriads of hyaline spores through which the fungus is propagated (See Fig. 22, p. 288). In these early stages of the disease the fungus may be plated out in almost pure culture by a surface sterilizing of the infected material. This is not true later, however, as these infested areas soon become confluent, the tissues die and break open, following which, bacterial and fungus contaminations set in. (See Figs. 15, 16, 17 and 18, pp. 279, 280 and 281).

In the preliminary attack, the disease causes no foliage change through which the trouble may be distinguished, unless lesions are formed directly on the leaves, which seldom occurs in the seed bed (See Fig. 20, p. 284). Seedlings about to collapse with the disease take on a bluish red color of the foliage. The growers, as a rule, discard all plants observed to have stem or leaf injury from this or other cause.

The dissemination of the disease is not so much a matter of overlooking the planting of infected seedlings, though undoubtedly much of this takes place, as it is of general distribution of spores through the handling of occasional sick plantlets.

Plants affected with this trouble die in all stages of their growth; few, however, succumb previous to the transplanting, and only those more or less badly affected at the time of setting out die within the following three weeks. The greatest loss takes place at the time when the plants are one-half to two-thirds grown, at which time the symptoms are very characteristic. The foliage of the affected plants takes on at the margins a mottled, metallic, bluish-red color. The lower, outer leaves show evidence of wilt. Total collapse may take place in 24 to 48 hours (See Fig. 4, p. 265, plant at right). Examination of the stems and roots of partially matured, infected plants always reveals large, sunken lesions extending one-half to two-thirds the distance through the stem or sometimes showing a sunken collar-rot, so far destroying the stem as to allow the top to break off easily, and as Mr. Guy Wickert of Fremont says, "Uproot and blow away with the wind." (See Fig. 7, p. 268 and Fig. 18, p. 282).

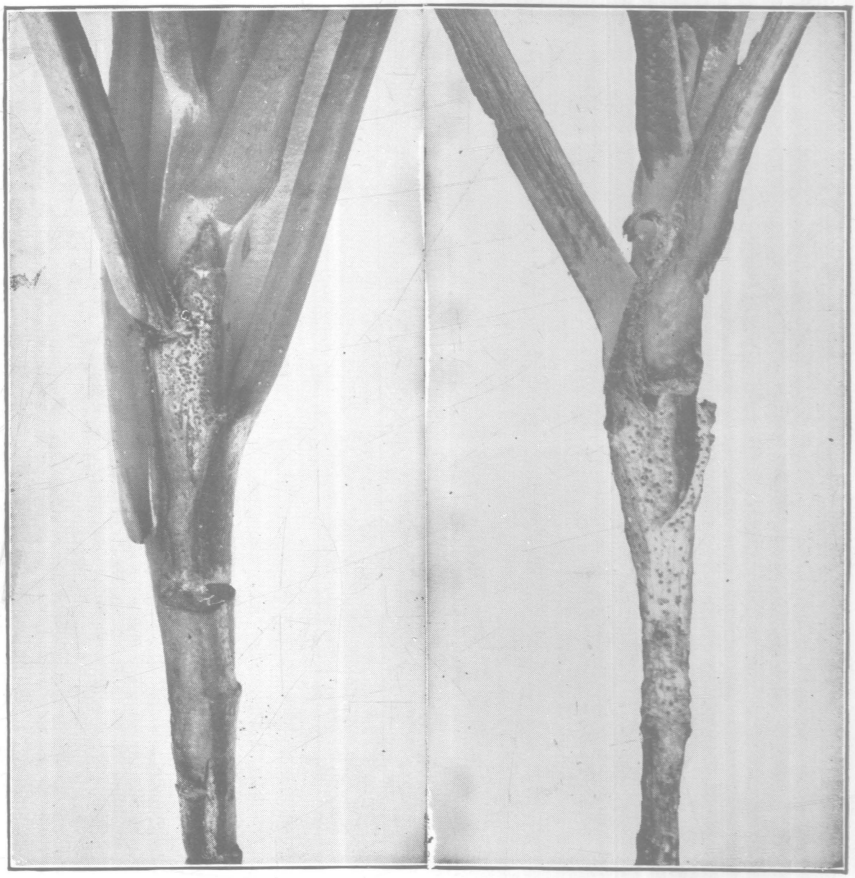

Fig. 15 Fig. 16

Seedlings of cabbage magnified by 1.8 and 3 diameters respectively showing the early stages of "Black-Leg" or Phoma wilt. Plants taken from the seed bed at transplanting time. Observe in the plants the infected area containing many fruiting bodies (black dots, called pycnidia) of the fungus *Phoma oleracea* Sacc. which is the cause of the disease.

If rains are favorable, the infested plants may set root again from above the place of injury. (See Fig. 18, p. 282). These adventitious roots are seldom sufficient to mature a marketable product.

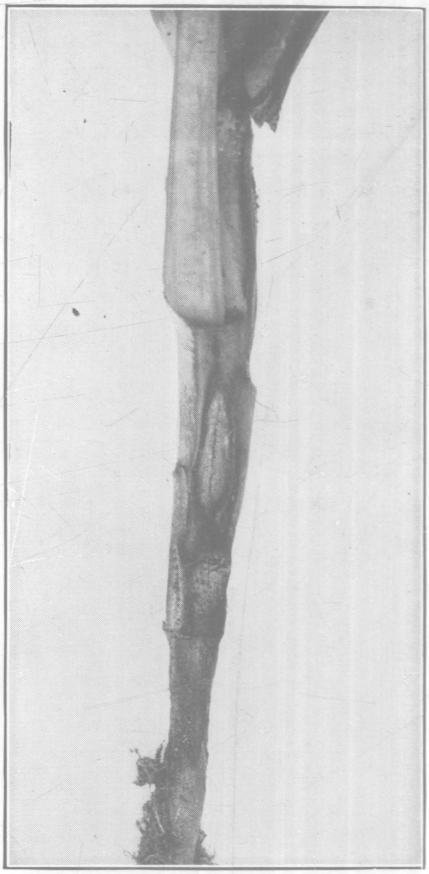

Fig. 17. Plant taken from the seed bed at transplanting time, showing infection just above the rootlets, in which a collar-rot is taking place.

CAUSE OF THE DISEASE

The disease has been associated in the past by some with insect work, hence, much error has been connected with its diagnosis. It hardly seems probable that it has not been noted in the United States heretofore by plant pathologists. F. L. Washburn[8], State Entomologist for Minnesota, in his report to the Governor for 1906, states, in writing upon club-root of cabbage: "Many market gardeners confound the work of the maggot with diseases which affect the root and have no connection whatever with maggot. This is noticeably true of a form of rot which sometimes affects the roots, causing wilting and death of the plant." It appears very probable that the above writer is referring to what is here called *Phoma* wilt or "black-leg," as it is the only fungus rot of the cabbage root.

In Australia, McAlpine makes no mention of insects being associated in causing the trouble. Prillieux, in his work on plant diseases, in no way refers to the disease being favored by insect activity. On the other hand, Bos and Quanjer in Holland, following their experimental work, claim that the disease is quite closely associated with the activity of the cabbage maggot. Indeed, Quanjer goes so far as to state (see Cit. 3, p. 266,):

[8]Washburn, F. L., Report of State Entomologist, Minnesota, 1906.

"The control of the drop disease depends chiefly upon the proper control of the cabbage fly. Since nature, in an epidemic of these parasites, has not as yet come to our assistance, it is left to us to overcome this difficulty; accordingly, we will be directed towards preventive means. One should clean the plantlets, before placing in the field, by washing away the adhering earth and by cautiously rubbing the stem and the leaf axes in order, if possible, to destroy the clinging eggs of Anthomyia (the cabbage fly) and Baris (the cabbage curculio[8]). After planting, the stems of the plantlets should be protected from the cabbage fly. However, the paper collar, which I have mentioned above, for this purpose is quite inadequate, because through the thickening growth it is subsequently brought into an improper position. More practical is it to throw a handful of slacked lime about the stem. In a limited way, this method has been proven; however, it will be tried extensively this year in the experiment fields of Langendijker."

Bos states (see Cit. 2, p. 260) that, in the order of their susceptibility to the disease, the red cabbage is first, then Savoy and Danish head cabbage, and last, though in a much less degree, cauliflower.

McAlpine (See Cit. 5 p. 276) notes that the disease is most severe in cauliflower.

Washburn,[9] in working with the cabbage maggot states "Holland cabbage appears to be exempt from attack, no cabbage maggots being found in this variety. Red cabbage, on the contrary, is not immune, since it suffers from the attacks of the maggot."

In speaking of the maggot work on cauliflower the same author says: "The cauliflower was a complete failure, there being only three heads out of the fifty plants when counted July 26th."

I quote from the different writers above, to show that much variation takes place. For example, in Australia cauliflower is most subject to the disease while in Holland it is least. In Minnesota, Holland Cabbage is exempt from the work of the maggot, while in Holland it is more subject to the Black-leg than the cauliflower. As previously noted (p. 280) Washburn states there is a root rot and wilt of the cabbage which has no connection whatever with the maggot.

The observations made by the writer in the seed beds and fields, together with experiments upon seedlings of the varieties "All Season" and "Market Garden," convince him that the importance of insect association, as noted by Bos and Quanjer in Holland, does not apparently hold true for the disease in our districts. In fact, the disease was produced in abundance in seedlings by placing washings from diseased material with the seed at the time of planting. Many of the plantlets died before the third leaf was formed (See Fig. 20, p. 284). No association whatever of maggots was found with this early seedling infection.

[9]Washburn, F. L., Bul. Minn. Exp. Sta., 112: 1908

[8]The insertions in the parentheses are the writer's. It appears that *Baris rapae* and *Ceutorhynchus rapae* Gyll. are synonyms. (10) See Bul. Ohio Agr. Exp. Sta., 77, Feb. 1897, by F. M. Webster.

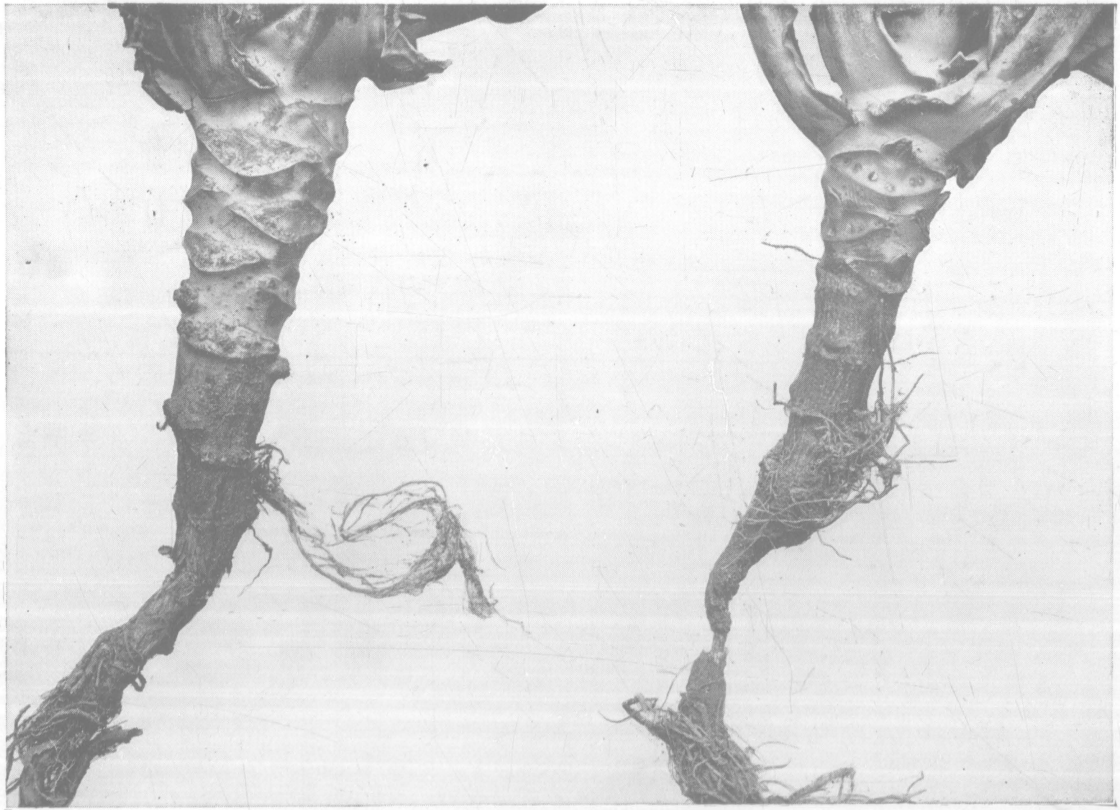

Fig. 18. 'Black-Leg" or Phoma wilt in the advanced stages. Showing the stem completely rotted off and the foliage collapsed (wilted). The plants have attempted to re-establish themselves by throwing out adventitious roots above the point of injury.

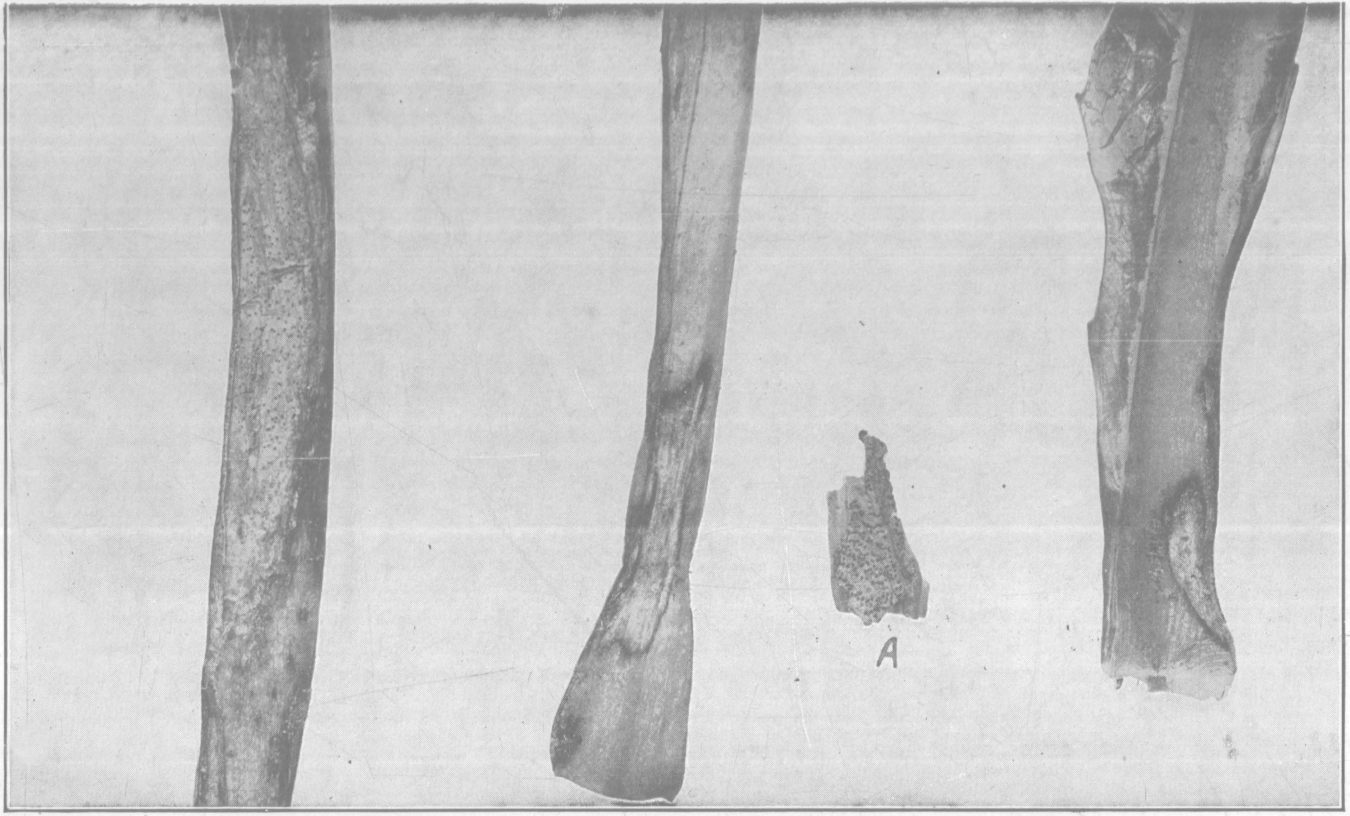

Fig. 19. Showing the "Black-Leg" fungus *Phoma oleracea* producing cancerous spots on the petioles and blades of cabbage leaves. Note at the left the fruiting bodies of the fungus scattered evenly throughout the lesions. The small piece marked A, which is also covered with fruiting bodies was taken from a decaying leaf blade.

Fig. 20. Showing seedlings of "All Season" the variety of cabbage infected on the leaves with the fungus (*Phoma oleracea*) which causes "black-leg" or "foot-rot." In the seedling at the left the disease has entirely rotted off the stem above the seed leaves.

Direct experiments with pure artificial cultures of *Phoma oleracea*, inoculated into the stems of half matured cabbage plants just below the surface of the ground by means of a slight cut into the cambium with sterile scalpel, gave 100 percent of infection. One of the plants showed a total collapse from a collar or cambium rot. Several others would have succumbed in a short time as the cambium was nearly destroyed.

The incisions made in the check plants healed up nicely with no evidence of rot.

I have seen maggot borings at four or five places on a single cabbage stem and root without any evidence whatever of rot following. Wherever *Phoma* "foot-rot" is found associated with the maggot work, it simply means that the insect has made it easier for the fungus to get a foothold.

In examining a large number of *Phoma* wilted plants in the Clyde district, by cutting longitudinal sections of the injured roots, only three showed insect work, in which case the larvae associated appeared to be those of the small flies which are common in rotting vegetables. In one case two white maggots about 7-20 of an inch in length, were present; these upon pupating, turned brown and were between 3-20 and 7-40 of an inch in length. These measures correspond closely to those of the cabbage maggot.

The direct cause of the disease is a fungus, scientifically known as *Phoma oleracea* Sacc. The arrangement of the fruiting bodies (pycnidia), their size, ¼ to ⅓ millimeter in diameter, together with the spore measurements (4.5 to 5 m. m. m. by 1.7 m. m. m. to 2 m. m. m.), and other characteristics, all indicate the organism to be the above named fungus.*

There is little doubt that insects, viz., the cabbage maggot, the cabbage curculio and wireworms may be and quite generally are instrumental to some degree in distributing and facilitating the fungus in its work on the cabbage. On the other hand, the evidence is sufficient to show that the fungus is a direct pathogen on seedlings and susceptible plants. (See Figs. 15, 16, 17, 19, 20). Under

*Some discussion should be given here to the assigning of *Phoma Brassicae* Thüem. as the causal organism of this disease by Prillieux in France and McAlpine in Australia. According to Bos (see Cit. 2 p. 260) there is reason to believe that the organism assigned by Prillieux viz., *Ph. Brassicae* Thüem. is identical with *Ph. oleracea* Sacc. In the description of the two species, *Phoma Brassicae* and *Phoma oleracea*, (See Saccardo, Sylloge Fungorum, III, 119 and 135), as far as measurements are concerned, there is hardly difference sufficient for any specific distinction. On the other hand, the arrangement and number of pycnidia would seem to be a basis for such distinction, to wit:
"*Phoma Brassicae* Thüem. Peritheciis majusculis, dense aggregatis, saepe confluentibus * * superficialis; sporilis * * 3-4=1.5-2. mmm"
"*Phoma oleracea* Sacc * * Peritheciis sparsis, globosso-depressis, papillulatis, ¼-½ mill. diam., * * sporilis 5-6=2 mmm., 2 guttulatis, hyalinis."
Prillieux's illustration of the pycnidium (See Cit. 7 p. 276) shows the pycnidia to be arranged singly and submerged, similar to *Phoma oleracea*.
McAlpine, on the other hand, in his Plate VII (Cit. 5 p. 276) shows photo-micrographs in which the pycnidia are superficial and densely aggregated. These distinctions would seem to justify McAlpine in designating the organism as *Phoma Brassicae*.

warm, damp storage conditions the fungus spreads rapidly. In shipping by express a number of infected plants from Clyde, Ohio, in which the shipment was five days in transit, the disease spread rapidly over the plants, fruiting abundantly on the partially wilted leaves.

LOSSES FROM THE DISEASE

This disease is much more irregular in its work than is the Fusarium wilt. The latter gradually increases, but most surely comes to stay. On the other hand, the Phoma wilt may be found only upon 5 percent of the plantlets in the seed bed, and yet become so thoroughly disseminated during transplanting as to cause almost a total loss. Several fields this season (1910) have shown losses varying from 20 to 70 percent, the disease coming directly from the seed bed. In 1909 almost total losses were caused in several of the fields which had previously never grown cabbage. Evidence has been obtained in which heavy loss came about from previous field infection. At Fremont there were sick spots of one-fourth acre or more in size in the fields which would indicate previous soil infection. Infection and dissemination at transplanting time is indicated by certain rows being badly infected, or by a quite uniform percentage of infected plants throughout the field, as contrasted with sick areas where previous soil infestation occurs.

INFLUENCE OF SOIL AND WEATHER

Growers in the Clyde district make the statement that the "Wilt" (black-leg or Phoma wilt) makes its greatest progress on the black soils. The observations made this season by the writer partially confirm these statements. The disease, however, is in no way strictly confined to the heavier soils. This season the loss in a field on about the lightest soil in the vicinity of Clyde was over 5 percent from this disease on an area which had not previously grown cabbage.

Moisture appears to be more favorable than the soil texture as a factor influencing the spread of the disease. In seasons which are moist throughout, the distribution and activity of the fungus is greatly accelerated.

TREATMENT

This disease is a soil trouble which carries over from season to season through infected stems and leaves. As a rule, persistent soil parasites do not submit readily to treatment. There are, however, exceptions to this statement, and the writer is inclined to believe that in this organism we have such an exception. The kinds of soil organisms which do submit to treatment are usually those which cause a stem rot at level with, or just below the surface

of the ground. Rolfs[12], of Florida, has found that by spraying the ground around the stems of tomatoes with ammoniacal copper carbonate, he could successfully control the sclerotium blight. In Cuba[13] the use of Bordeaux mixture, when sprinkled thoroughly on the tobacco seed beds, controlled bed rot (a disease caused by Rhizoctonia) "with complete success."

McAlpine (see Cit. 5, page 276) has found that a strong solution of bluestone is very effectual in controlling a serious soil disease of tobacco, when the solution is applied the same day the seed is planted. He recommends for this disease (Phoma wilt) that the seed beds should be treated, preparatory to sowing, with a fungicide such as sulphate of copper.

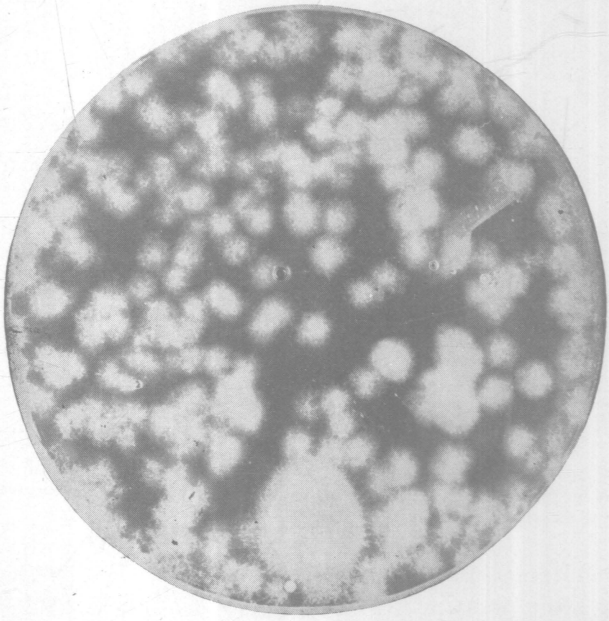

Fig. 21. Showing plate culture of *Phoma oleracea* Sacc. on an artificial medium The white fungus growth came from small spores taken directly from a pycnidium (spore sac) see B. Fig. 22.

The writer has experimented upon the use of both Bordeaux mixture and a straight solution of copper sulphate (bluestone) for this disease upon cabbage seed beds at time of planting and upon seedlings three weeks old. The formulas used were, for the Bordeaux, 4 lbs. copper sulphate, 4 lbs. lime, to 50 gallons of water—and in the straight copper sulphate solution, 4 lbs. of copper sulphate to 50 gallons of water.

[12]P. H. Rolfs, Tomato Diseases, Bul. Fla. Agr. Exp. Sta. 91: 1907.

[13]Estacion Central Agronomica, Cuba, Cir. No. 28: 1907 and Circ, No. 30: 1908 Eng. Ed. "Soil Sterlizing, Bordeaux Mixture and Poisons for Tobacco Seedbeds" by William Titus Horne.

The solutions were used in two different amounts. The Bordeaux at the rate of two gallons per 10 square feet and one gallon per 10 square feet. The copper sulphate solution was used at the rate of one gallon per 10 square feet and one-half gallon per 10 square feet.

The Bordeaux mixture in no way retarded the growth of the seed or injured the seedlings; on the other hand, the copper sulphate solution, though apparently in no way retarding the germination, considerably scorched the leaves of the seedlings.

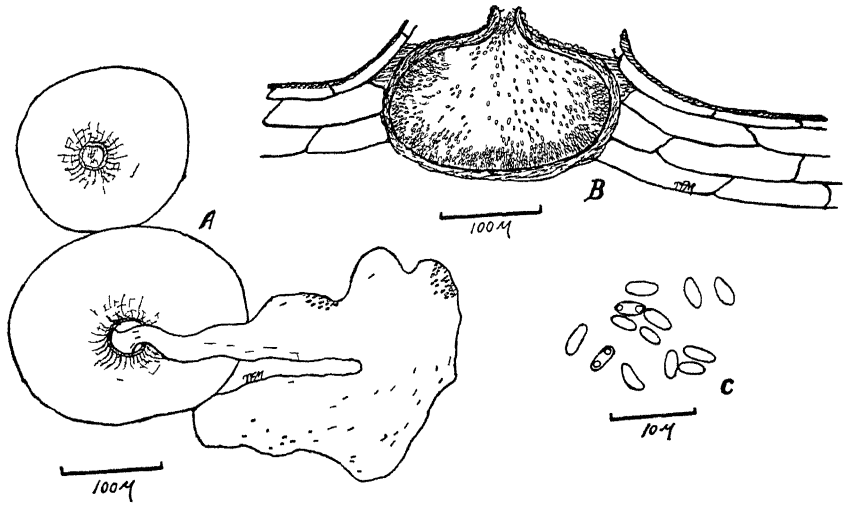

Fig. 22. A, showing fruiting bodies (pycnidia) with spores streaming out in a mass Slight pressure brings out myriads of spores from each spore sac, every spore being capable of reproducing the fungus of the disease (Highly magnified)

The writer would recommend treating the seed beds, immediately after planting, with a Bordeaux mixture (4-4-50 formula) at the rate of one gallon per 10 square feet. Use a sprinkling pot, or a foot spray pump. The bed should again be sprayed, using a spray pump, two weeks before transplanting, and again just before transplanting. These treatments will keep the disease down in the seed bed, and prevent distribution of the disease during transplanting.

Quanjer (see quotation p. 281), in Holland, states that a handful of slaked lime thrown about the stem after transplanting has worked satisfactorily in keeping the disease in check. Though this has not been tried by this Station, it would seem worthy of trial by cabbage growers and it is recommended to such by the writer.

OTHER MEASURES LOOKING TOWARD CONTROL

Too much emphasis cannot be placed upon prevention. We must remember that in new areas being devoted to cabbage growing none of these troubles, as a rule, is present. Their introduction and wholesale distribution are due to a combination of our indifference, our ignorance of their manner of coming, and to our failure in using precautionary measures for prevention. Since the cabbage maggot and other insects are in a measure instrumental in furthering this disease, much effort should be centered on keeping down these pests. No better means is afforded than the destruction of the material on or in which they breed. This is almost as true with regard to certain fungus diseases. Destruction prevents distribution. Washburn (see Cit. 9, p. 280) in Minnesota, has had some success in controlling the maggot with white hellebore. Keep in touch with your Entomologist at this Station for methods of destroying these insect pests. Washburn (same Cit.) finds that the Holland cabbage is exempt from the maggot attack (see p. 281.) Hence, grow varieties free from the work of this pest.

Too much importance cannot be placed on selecting areas for seed beds that are not already infested. Great care should be exercised in seeing that the disease is not carried to the seed bed by the shoes having previously crossed infested areas.

SUMMARY

1 The "Black-Leg" or Phoma Wilt is a severe cabbage disease which is causing much loss in certain districts of Ohio, page 286.

2 The disease is active also in Germany, France, Holland, and Australia, causing in certain districts much loss.

3 In non-infested districts it would seem possible to prevent the disease from getting a foothold by practicing seed treatment, page 259, and bed treatment, page 287-289.

4 In infested districts it is well to avoid the disease by placing the seed beds on non-infested soils. Infested fields should be placed under proper rotation.

5 Likewise, in older districts seed and bed treatment should be practiced. It would also seem advisable to try the lime treatment (see page 288.)

6 Whether the district is new or old it is recommended to change the seed bed to a new location every year. By so doing, both insect and fungus pests will be much avoided. Put out two or three seed beds some distance from each other. Use only those plants which are the most vigorous and healthy.

7 Use no plants from beds sick with the Phoma wilt or the Fusarium wilt ("yellows"). The appearance of sick plants in the bed most likely means that the whole bed has become infested.

8 Plow up the seed beds as soon as the transplanting is done. Old seed beds are fine breeding places for insect and fungus troubles.

9 In no wise allow stock to pasture promiscuously from infested to non-infested fields.

10 Prevent, if possible, infected cabbage litter from reaching the manure.

11 The chief means of distributing the disease is by handling at the time of transplanting, when the spores from the few infected plants are smeared upon the non-infected. Spray the seed bed thoroughly with Bordeaux mixture just before transplanting.

12 Much irregularity is found in the type and quality of cabbage in the Clyde and other cabbage districts. This comes about by purchasing a miscellaneous seed supply. Buy from reliable seed growers only.

13 To assist in determining the different diseases, make use of your Experiment Station.

14 Discuss plant diseases at your institutes.

NOTE: See page 275 for summary concerning Fusarium wilt (yellows)

HOW TO DISTINGUISH FUSARIUM WILT AND PHOMA WILT FROM OTHER CABBAGE TROUBLES

Although these newer diseases, in their symptoms, are quite different and distinct from some of the older troubles, for example, black rot (*Bacterium campestre* (Pam.) Erw. Smith) and maggot injury, yet many errors have been made during the present season by correspondents in the diagnosis of these troubles. Some of the reasons for this come from correspondents being familiar with only a part of the symptoms of each disease, and not being informed regarding each of the different cabbage troubles. Both black rot and Fusarium wilt cause yellowing and browning of the cabbage leaves; however, when we look into the symptoms further, we find that black rot usually begins its work of yellowing and browning of the leaves at certain points of infection on the margin (see illus., Fig. 23, page 292). These infected areas gradually enlarge until extensive brown lesions are formed; sometimes several such diseased spots are to be observed on a single leaf; often these spots become confluent and the whole leaf dies. There is little tendency of the leaf to break off and drop as in "yellows" (Fusarium wilt). One of the chief symptoms of black rot is the blackening of the leaf veins and veinlets (Fig. 23, p. 292). This is seldom found in "yellows". Accompanying black rot is always the strong odor of decaying cabbage, which is not a part of the Fusarium or Phoma wilt, except in cases where occasional wet rots set in.

Many errors are made in assigning the work of the Phoma wilt to that of the cabbage maggot. The symptoms are quite different in each case, but owing to the maggot assisting in spreading the Phoma wilt, the importance of the latter trouble is often overlooked. The gnawings, furrowings or borings of the maggots are quite conspicuous and characteristic, and the presence of the white larvae in the roots of the older plants (Fig. 24, p. 293) verify the diagnosis. The slower work of the maggots and the characteristic stunting of the plants differ entirely from the rapid work of the Phoma wilt.

Club-root, caused by a slime mold fungus (*Plasmodiophora Brassicae* Wor.) could hardly be mistaken for any of the other troubles mentioned, unless no examination were made of the distorted and enlarged roots. (Fig. 25, p. 294).

There is some possibility of confusing the work of the downy mildew (*Peronospora parasitica* DeBy) with the Fusarium wilt and black rot. Specimens of cabbage affected with the downy mildew have been received from the Lodi district (Medina Co.) this season.

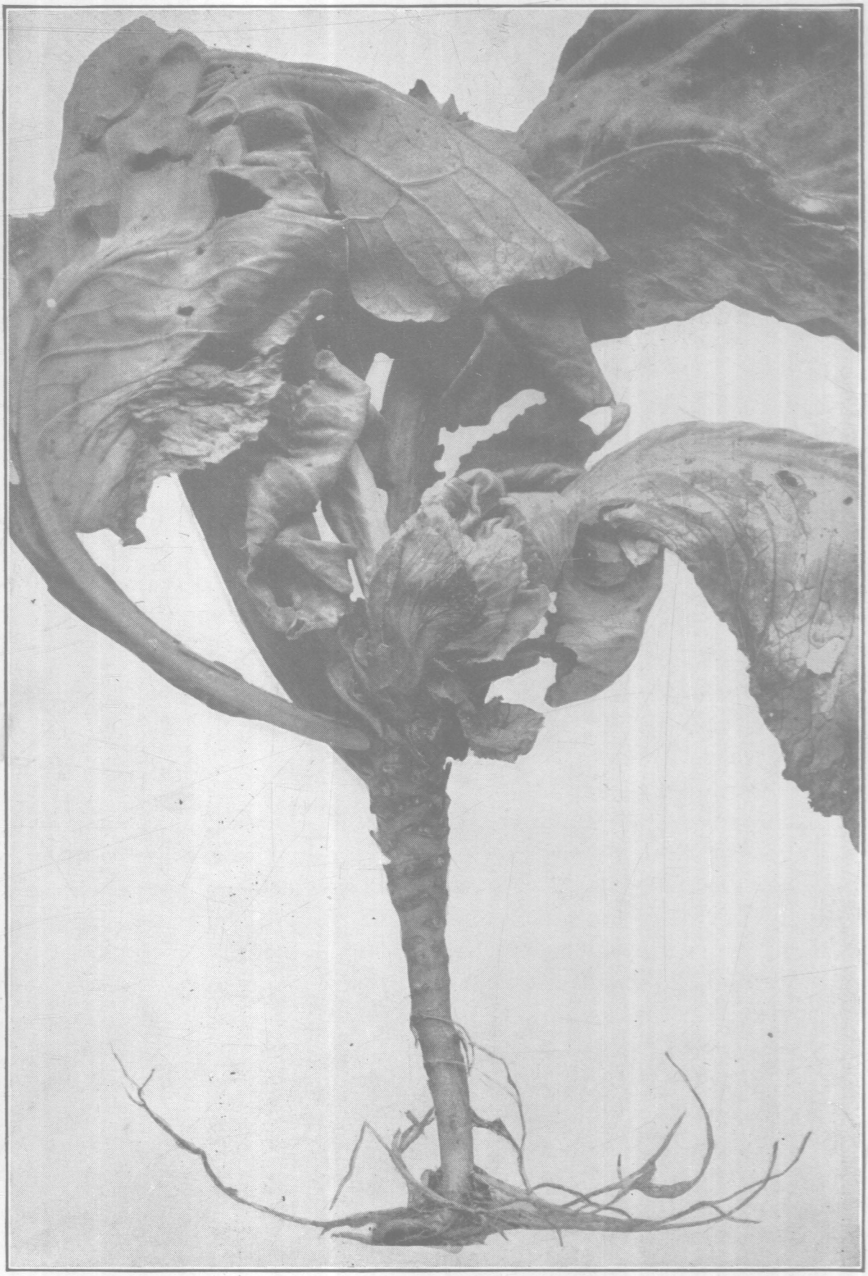

Fig. 23. Showing a cabbage plant affected with black-rot, a bacterial disease caused by the organism *Bacterium campestre* (Pammel) Erw. Smith.

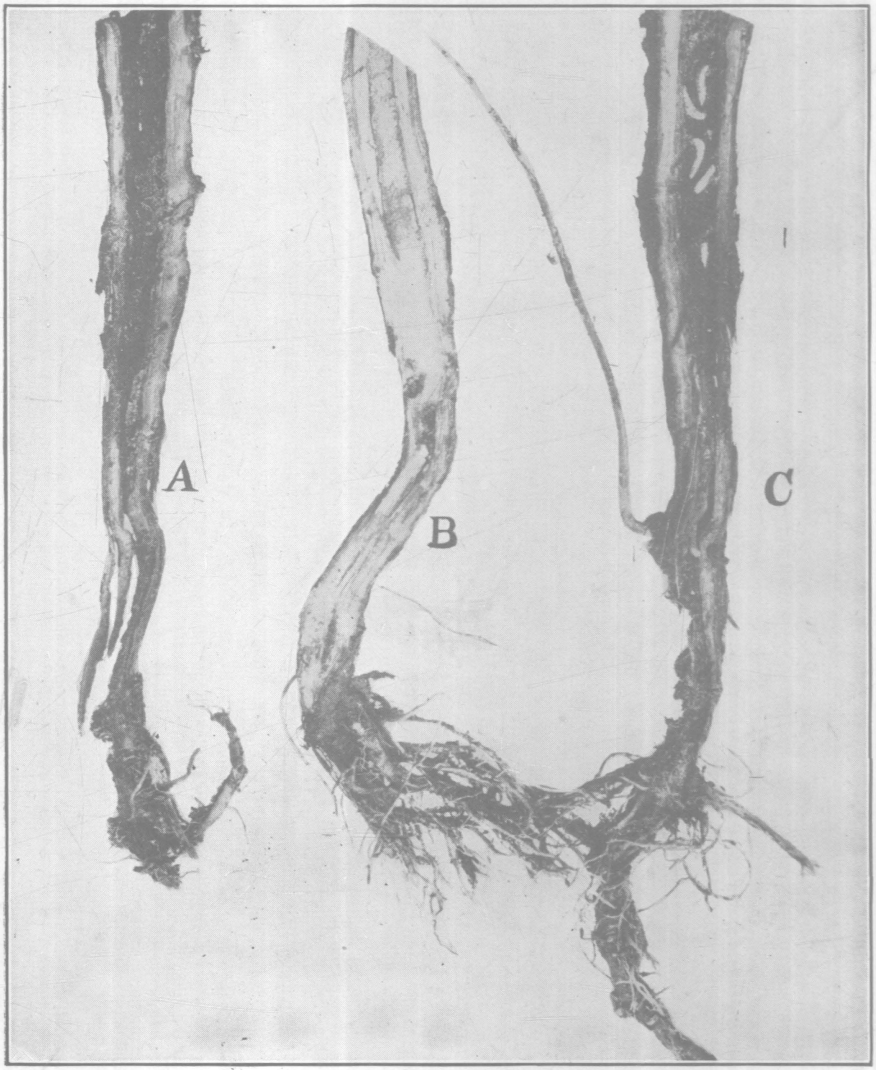

Fig. 24. "Cabbage roots injured by maggots: sections showing root badly injured both externally and internally (A), only on outer surface (B); both externally and internally, and maggots feeding within the root (C): from original Photo." This plate is used to contrast the work of maggots with that of the "Black-Leg" (Phoma wilt), see Fig. 18, page 282.

From Bul. 200: (1907), New Jersey Agr. Exp. Sta. Fig. 6 and description. "The Cabbage and Onion Maggots" (16), by John B. Smith, Expt. Sta. New Brunswick, New Jersey.

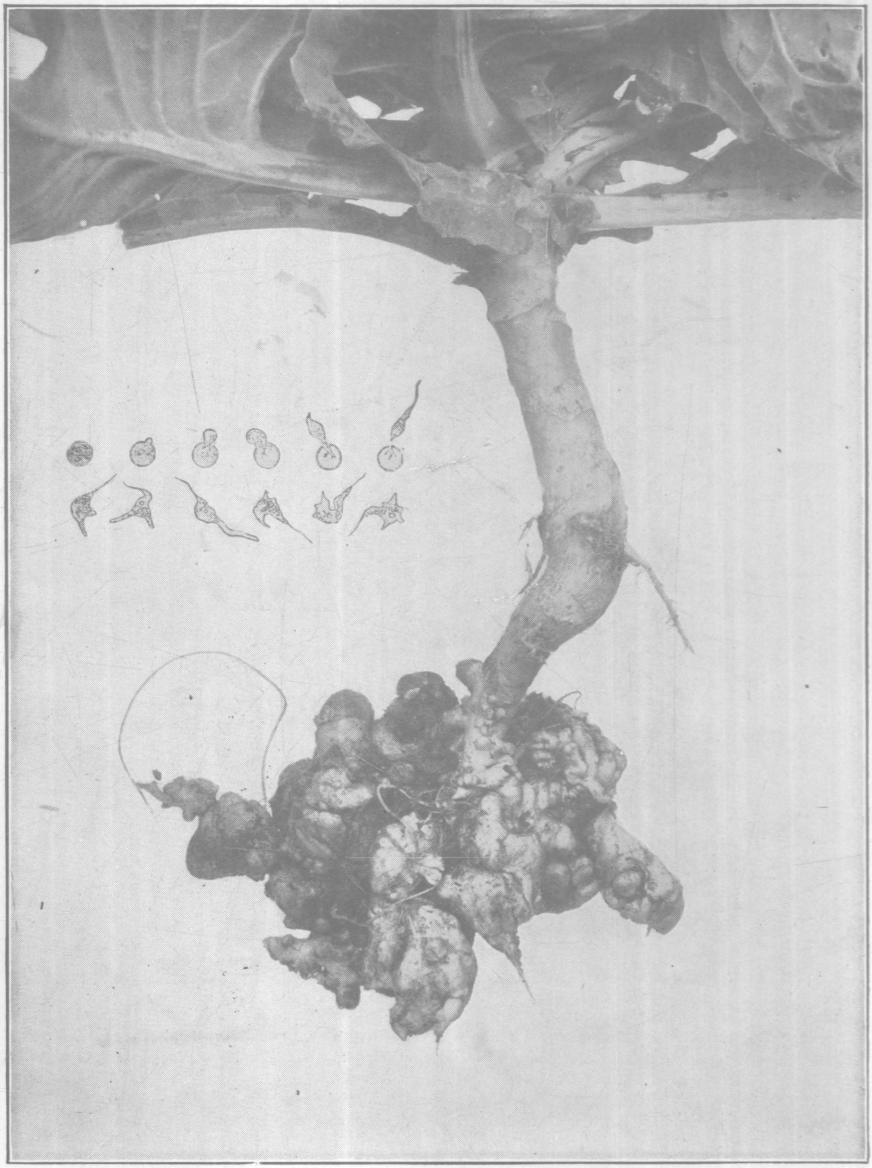

Fig. 25. Showing the club-root of cabbage, a disease caused by the slime mold *Plasmodiophora Brassicae* Wor. The development of the plasmodium is also shown. The latteris reproduced from a publication of the Dept. of Agr. Victoria—See Ref. 5 p. 276.

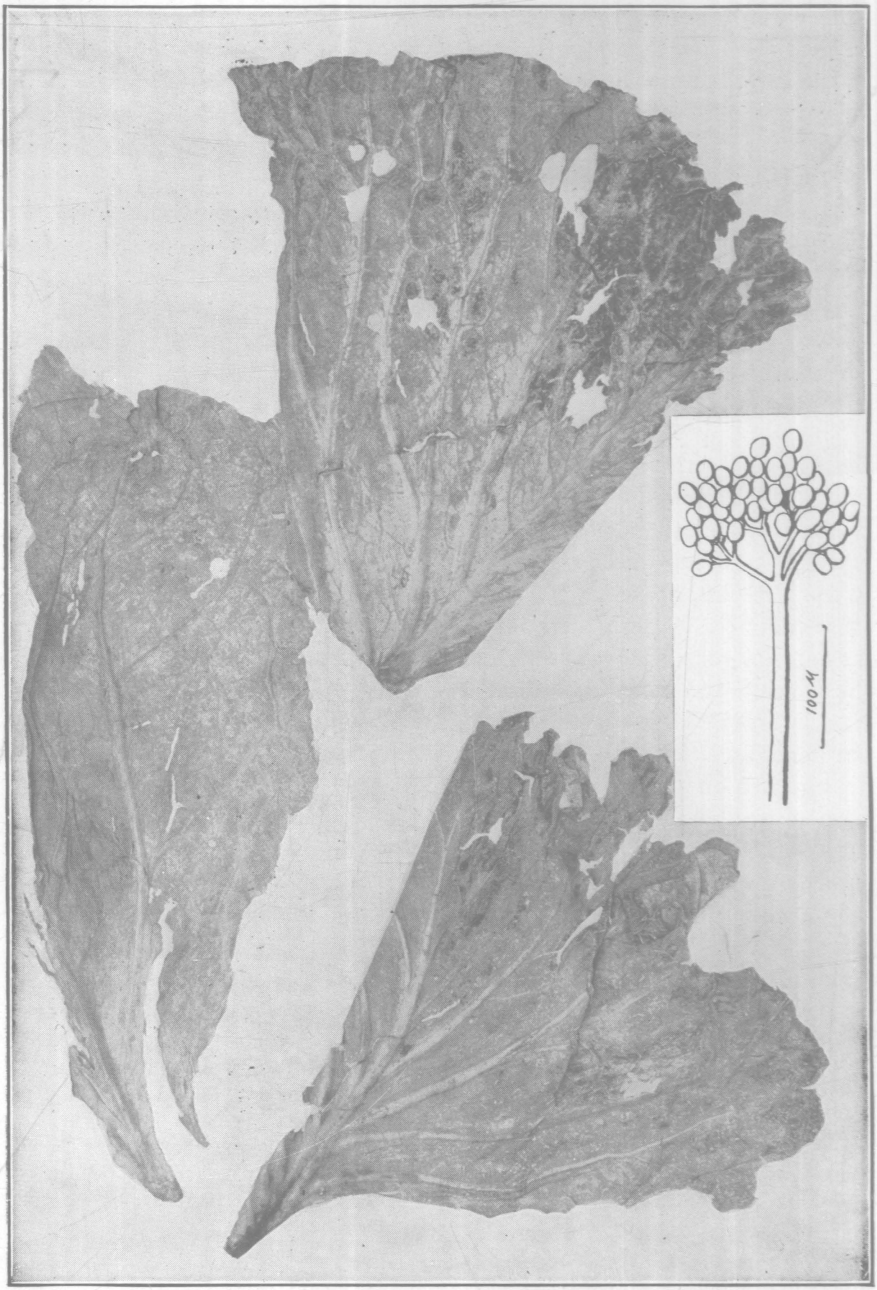

Fig. 26, Cabbage leaves showing the work and appearance of downy mildew. a fungus disease caused by *Peronospora parasitica* De By. (The fungus is shown highly magnified)

The symptoms are quite different from the Fusarium wilt, in that the leaves do not drop. The under surface of the leaf, in the infested areas, is covered with patches of the mildew. The fungus is not very conspicuous. Brown spots one-half to three-quarters of an inch in diameter are formed throughout the affected parts; large areas turn yellow and the texture of the leaf becomes very leathery. Other fungi quickly follow the work of the mildew, especially an *Alternaria* which blackens the affected areas. See the leaf in the right-hand, upper corner in Fig. 26, p. 294. Plants may become affected in the seed bed and continue throughout the whole season, but as a rule, only the older and nearly matured leaves are most severely affected.

COOPERATION INVITED

Owing to the lack of statistics giving data on the cabbage crop, much difficulty is met with in keeping in touch with the different cabbage districts. Information from several sources indicates that the crop is being taken up by farmers who have had little experience in the growing of cabbage, and much less with the many troubles affecting it. The Experiment Station invites cooperation. Assistance may be given the Station by sending in information of the acreage in each vicinity where cabbage is grown; whether the crop is on the increase or decrease, and why; the average tonnage per acre, and the value of the same; the date when cabbage was first grown on a commercial basis; whether old land responds to the crop as well as new; what diseases are prevalent and how severe each has become.

We can assist you by diagnosing the plant diseases, and by recommending treatment or measures for the control of the different troubles. Send in diseased specimens for identification. Ask for Bulletin No. 214, "A Brief Handbook of the Diseases of Cultivated Plants in Ohio."

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The illustrations are all those of the writer, or from material gathered by him or correspondents, with the exception of Fig. 24, from a New Jersey Station publication, and part of Fig. 25, from a publication of the Department of Agriculture, Victoria, for which credit is given in the description of these plates.

To Mr. Wm. Beeching, Jr., the Station photographer, is due credit for the photographing of Figs. 15, 16, 17, 20, 25 and 26, and for the excellent prints for all the illustrations.

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